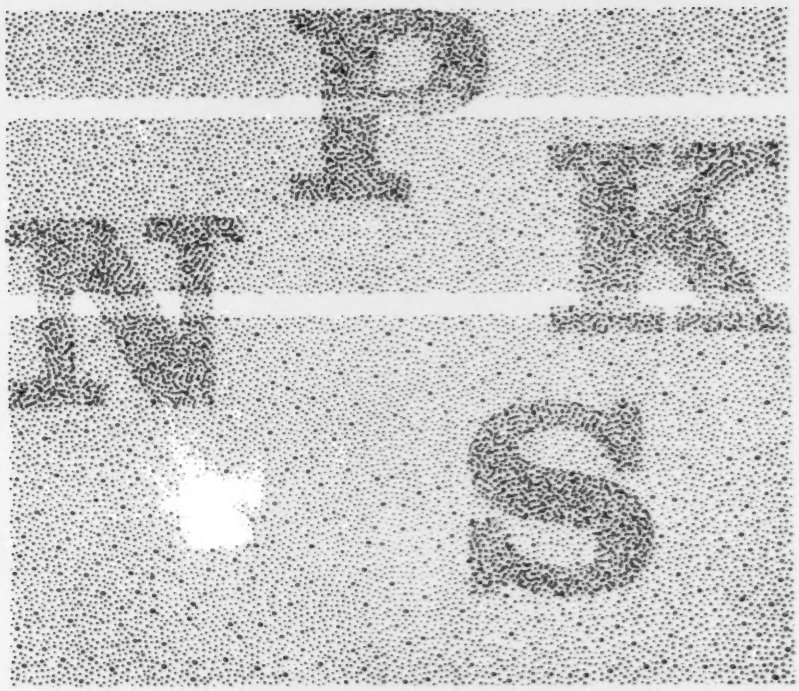

# fertilizers
## their properties, methods of storage and handling

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# FERTILIZERS: THEIR PROPERTIES, METHODS OF STORAGE AND HANDLING

## INTRODUCTION

Fertilizers must be used wisely and efficiently for optimum crop production. This guide discusses the various types of fertilizers available in Alberta, and the best methods of storing and handling them. The advantages and disadvantages of each fertilizer are included.

## NITROGEN FERTILIZERS

### Anhydrous Ammonia (82-0-0)

Anhydrous ammonia under normal air pressure is in the form of a gas. It is kept in liquid form under its own vapor pressure in closed tanks and cylinders. The chemical formula for anhydrous ammonia is $NH_3$. The properties of this fertilizer are given in Table 1.

**Table 1: Properties of Anhydrous Ammonia**

| | |
|---|---|
| Color | Colorless gas or liquid |
| Molecular wt | 17.03 |
| Boiling point | -33.4°C |
| Solubility | 89.9 g/100 g at 0°C |
| Specific gravity | 0.618 at 15.5°C |
| Weight per volume | 0.52 kg/litre (5.15 lb/gal) |
| Vapor pressure psig | 1455 kPa (250 psig) at 40°C |

**Storage and Handling:**

Anhydrous ammonia is normally handled in tanks or other equipment designed for a minimum operating pressure of 1724 kPa (250 psig) for transportation and application. For safety reasons, in instances of expansion of anhydrous ammonia in non-refrigerated tanks, filling is restricted to 85 per cent by volume. This applies to most pressure tanks that are used at field installations as well as the application equipment in Alberta. Liquid ammonia can also be stored and shipped in refrigerated equipment. Most of the refrigerated equipment used in Alberta is located at production plants. Anhydrous ammonia is transported from production plants to distribution outlets.

Presently, anhydrous ammonia is classified as a hazardous material and therefore special safety measures are mandatory for storage and transportation. Anhydrous ammonia is **not** poisonous but causes asphyxiation under high concentrations.

To install an anhydrous ammonia storage tank, approval is required from a number of agencies, which include:

- Municipal Planning Board
- municipal council
- local fire chief
- provincial fire marshal
- Alberta Transportation
- railway company
- Canadian Transport Commission
- Boiler branch, Alberta Department of Labour, and
- Alberta Environment.

Figures 1, 2, and 3 are schematic diagrams of a bulk plant layout and storage tank.

**Application:**

When anhydrous ammonia is knifed into the soil as a liquid, it immediately changes to a gas because of the reduction in pressure. The gaseous ammonia ($NH_3$) undergoes rapid conversion to ammonium ($NH_4+$). The conversion occurs when the ammonia picks up an additional hydrogen (H+) from water ($H_2O$) which is in the soil or from clay or organic material which can also donate hydrogen. After ammonium is formed, there are a number of things that can occur:

- conversion to nitrate ($NO_3$-) by soil bacteria
- absorption by plant roots
- utilization by soil microorganisms
- adsorption onto soil particles
- fixation within soil minerals.

Immediately after injection of anhydrous ammonia into the soil, a localized zone of ammonium is formed. The zone is horizontal and cylindrically shaped with a diameter of 3 to 10 cm (1 to 4 in.). The diameter depends on the rate of application, soil texture, soil tilth and soil moisture content. The ammonia has a sterilizing effect within the zone of injection on soil microorganisms. Only a small fraction of the soil in the field is affected and no permanent damage is caused. This effect does not normally last more than a few days. It is very important to note that anhydrous ammonia does **not** have a detrimental effect on the soil microbial life in the long term.

Anhydrous ammonia is normally injected at a depth of 7 to 15 cm (3 to 6 in.) with a typical shank spacing of 20 - 40 cm (8 to 16 in.) being common. This method of applying fertilizer is commonly referred to as deep banding. It has the advantage of distributing nitrogen deeper into the rooting zone where soil moisture conditions are likely to be more favorable for root growth and plant uptake than if nitrogen fertilizer is applied at or near the surface.

The preferred time for applying anhydrous ammonia for small grains is before seeding. Under conditions in Alberta, research has shown that, in terms of crop yields, there is little difference between fall and spring applications, especially in dry areas. Spring applications do have the disadvantage of deeply working the soil which will result in loss of soil moisture. This application does have the advantage of combining one cultivation with an efficient

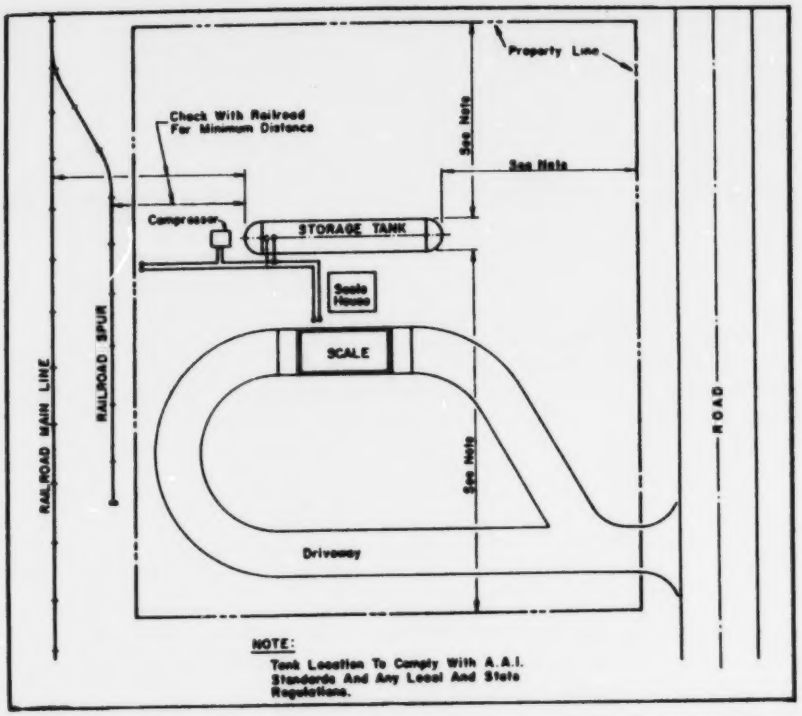


*FIGURE 1: Schematic diagram of a bulk or station layout for the storage and retail distribution of anhydrous ammonia, showing the principal distances which should be checked with the proper authorities before the plant is installed.*

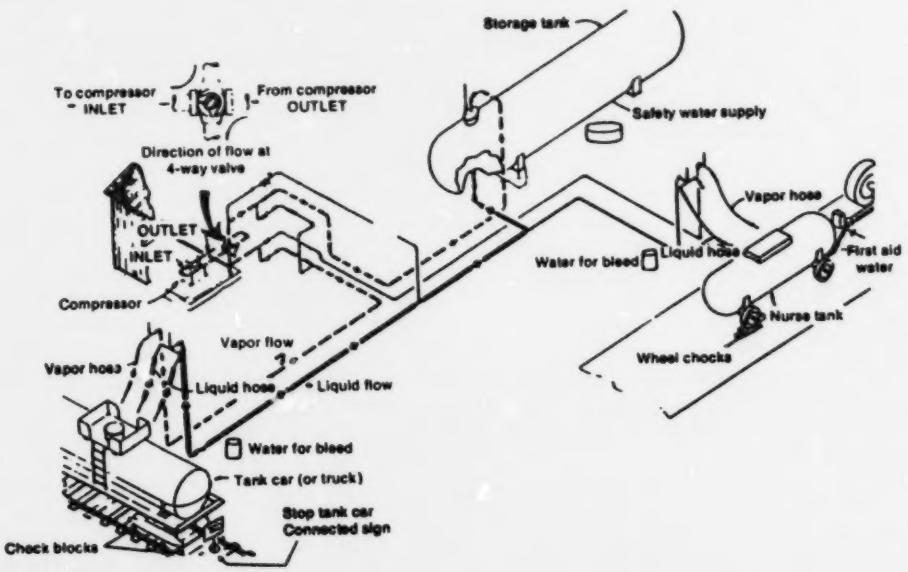


*FIGURE 2: Schematic diagram showing the bulk plant layout with railcar, compressor unit, storage tank and nurse tank.*

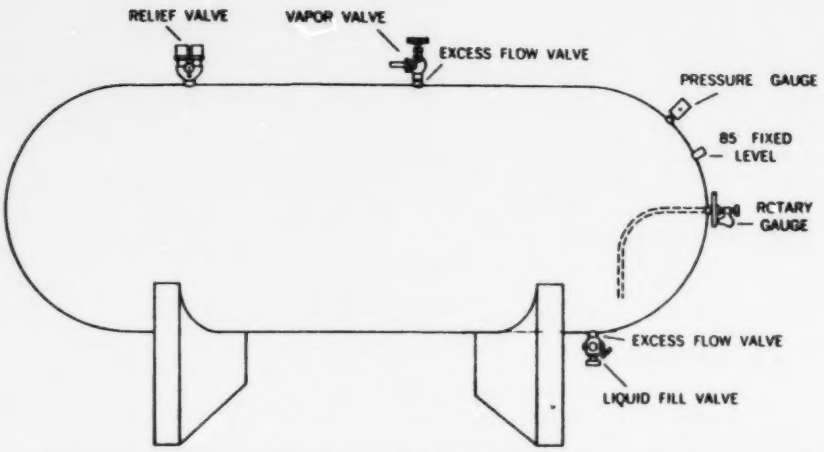


*FIGURE 3: Schematic drawing of a storage tank with valves and fittings. Most storage tanks are also equipped with temperature gauges. The exact location of the valves and fittings will vary from tank to tank. On many tanks the vapor valve is located on the underside of the tank with a tube extending up to the vapor space.*

method of fertilizer application.

There is some concern about the time interval between the time of application of anhydrous ammonia and seeding. Generally, it is safe to seed 24 - 48 hours after application. Harmful effects can be avoided by increasing the depth of injection to 15 - 18 cm (6 to 7 in.) or waiting 5 days before seeding.

Anhydrous ammonia can also be side dressed with row crops. This method of fertilization has not been widely used in Alberta. Care must be taken to place the fertilizer from 15 - 20 cm (6 to 8 in.) deep and still keep the shank 20 cm (8 in.) to the side of the row to reduce injury to plant roots.

Anhydrous ammonia can be used in conjunction with other fertilizers. These include deep banding with dry granular fertilizers or "double shooting with liquid phosphate fertilizers". These applications are discussed in Alberta Agriculture's *Fertilizer Application Equipment* Agdex 542-6.

**Anhydrous Ammonia Safety:**

Ammonia is a highly reactive and hazardous compound. However when handled wisely and safely using proper equipment, it is normally the most economical source of nitrogen fertilizer.

The ten ammonia safety commandments are:

- always have an ample water supply available
- always stay clear of hose and valve openings
- always wear gloves and goggles when transferring ammonia
- always close valves and disconnect hoses when plant is unattended
- always be sure pressure is relieved before disconnecting hoses or parts
- never fill a tank to over 85 per cent of its capacity
- never leave transfer operations unattended
- never tamper with relief valves or safety devices
- never try to "get by" - use only approved ammonia equipment
- never tow a trailer without secure connecting parts and safety chain.

If $NH_3$ escapes into the air, whether by accident or carelessness, the easiest way to detect the leak is by the smell. Ammonia has a very sharp pungent odor, and this is the first warning sign. If skin comes in contact with ammonia, severe injury may be caused by the tissue freezing and dehydration burns can add to the severity of the injury. The best first aid treatment is to immediately leave the contaminated area, flush the affected skin with large quantities of water and remove any contaminated clothing. Even in minor accidents, a medical doctor should be consulted for treatment.

## Urea (46-0-0)

Urea is a granular nitrogen fertilizer. It is made by combining carbon dioxide with anhydrous ammonia under high temperatures. The chemical formula for urea is $CO(NH_2)_2$. The properties of this fertilizer are given in Table 2.

**Table 2: Properties of Urea Fertilizer**

| | |
|---|---|
| Color | White crystals (prills or granules) |
| Molecular wt | 60.06 |
| Melting point | 132.7°C |
| Solubility in water | 66.7 g/100 g at 0°C |
| pH | 7.3 |
| Loose bulk density | 737 to 769 kg/m³ (46 to 48 lb/cu ft) |
| Angle of repose | 28° |

**Storage and Handling of Urea:**

Urea is very easy to handle and store. It is non-acidic and is less corrosive to equipment than other granular

sources of fertilizers. Safety precautions are not necessary as urea is not sensitive to fire or explosion. Urea does not absorb moisture from the air to the same extent as ammonium nitrate, therefore there are fewer problems of sticking and caking.

The advantage of urea is that it has a high nitrogen content, therefore there are some savings in handling, storage, transportation and application. The high nitrogen content as compared to other fertilizers means a reduction in the number of trips in trucking and spreading the fertilizer, as well as bin space and even rail car numbers to handle a specific amount of nitrogen. However, urea has a low bulk density compared with ammonium nitrate, which partially offsets the handling benefits associated with its higher nitrogen content.

Urea should not be mixed with ammonium nitrate fertilizers. Both products store well alone, however, when mixed they strongly absorb atmospheric water. The result is that within a few hours of mixing the solid mixture becomes a slurry. Even one per cent of either product mixed with the other can cause a problem.

**Applying Urea:**

Urea can be applied using several methods:

- broadcast and incorporated
- deep banded
- drilled in with the seed.

Urea in its initial form is quite mobile in soil. However, urea converts to ammonia ($NH_3$) and then to ammonium ($NH_4$+) shortly after application to the soil. When in the ammonia ($NH_3$) form, considerable losses due to volatilization (changing to a vapor) can occur under any of the following conditions when urea is applied to the soil surface and not immediately incorporated:

- dry, warm weather for several days particularly on sandy or alkaline (high pH) soils
- when air temperatures are above 10°C or soil temperature above 5°C, or
- on heavy trash surfaces that prevent fertilizer contact with the soil.

Therefore, if urea is broadcast onto soil, incorporation should immediately follow to prevent nitrogen losses.

Placing urea in the seed row can be harmful to seedlings. This is because of the liberation of ammonia and the resultant increase in soil pH can damage germinating seedlings. This is a major disadvantage in using urea on sandy soils and soils of low moisture status. Maximum rates of urea applied when seeding grain on moist sandy soils is 9 to 18 kg/ha (10 to 20 lb/ac) of actual nitrogen, and on moist fine textured soil (clay and clay loam) the maximum rate is 27 kg/ha (30 lb/ac). Lower rates should be used on dry soils or when seeding canola. No urea should be placed with flax when seeding.

Side banding or deep banding has been found to be a very efficient method of placing urea. The harmful effects of urea placed in the seed row can be eliminated by banding.

## Ammonium Nitrate (34-0-0)

Ammonium nitrate fertilizer is the only commonly used solid fertilizer which contains nitrogen in the nitrate ($NO_3$-) form. The chemical formula for ammonium nitrate is $NH_4NO_3$. The properties of this fertilizer are given in Table 3.

**Table 3: Properties of Ammonium Nitrate**

| | |
|---|---|
| Color | White crystals (prills or granules) |
| Molecular wt | 80.05 |
| Melting point | 170.4°C |
| Solubility in water | 118 g/100 g at 0°C |
| pH | 5.5 |
| Loose bulk density | 913 kg/m³ (57 lb/cu ft) |
| Angle of repose | 25° |

**Storage and Handling:**

Ammonium nitrate is considered to be a hazardous material because of its combustible and explosive properties. Strict transportation and storage requirements are in force and regulations are covered in the Canadian Board of Transport Commissioners Order #0-36.

Ammonium nitrate is not in itself dangerous or difficult to handle but it has picked up a bad reputation because of improper storage and handling. If ammonium nitrate comes in contact with oxidizable carbonaceous materials, such as oily substances, petroleum, diesel fuel, fuel oil, herbicides, pesticides, other oily or combustible substances, elemental sulfur or powdered metals, they are capable of making ammonium nitrate more combustible. If highly contaminated with any of these agents it may become explosive.

Ammonium nitrate absorbs moisture from the air when the relative humidity exceeds 59 per cent at 30°C. Ammonium nitrate changes into a crystal form when the temperature rises and then falls below 32°C. This results in caking and weakens the granules. As mentioned in the section on urea, mixtures of ammonium nitrate and urea absorb atmospheric moisture and become impossible to handle.

**Application:**

Rapid crop responses to application of ammonium nitrate are attributed to the nitrate ($NO_3$-) portion of this fertilizer. This is the preferred form of nitrogen by plants for uptake. Ammonium nitrate can be:

- broadcast and incorporated in fall or spring
- deep banded in fall or spring
- topdressed in spring
- drilled in with the seed.

Ammonium nitrate is the preferred form of nitrogen for drilling in with the seed and for top dressing small grain crops up to three or four weeks after seeding. This is because the nitrate ($NO_3$-) portion of the fertilizer is mobile in the soil and is readily taken up by plants.

The disadvantage of this fertilizer is that the nitrate portion can be leached from soils, particularly on sandy soils or in areas of high precipitation or intensive irrigation. Applications of ammonium nitrate in these situations should be kept as close to seeding time as possible to minimize nitrogen losses. Recent studies suggest that losses of nitrate through denitrification and immobilization in decomposing crop residues are appreciable in soils of northern Alberta. Therefore, in central and northern Alberta, the practice of fall application of ammonium nitrate

should be discontinued in favor of applications shortly before seeding in spring. Maximum rates of ammonium nitrate applied with the seed should be 36 kg/ha (40 lb/ac) which is much higher than for urea.

### Nitrogen Solution (28-0-0)

Nitrogen solution fertilizer contains three forms of nitrogen; urea, ammonium and nitrate. Therefore, the nitrogen source provides crops with readily available nitrate as well as the longer lasting urea and ammonium forms. The properties of this fertilizer are given in Table 4.

**Table 4: Properties of Nitrogen Solution Fertilizer**

| | |
|---|---|
| Percent 34-0-0 | 39 |
| Percent 46-0-0 | 31 |
| Percent water | 30 |
| Salting out temperature | -17.8°C |
| Specific gravity | 1.28 at 21.1°C |
| Weight per volume | 1.27 kg/litre (12.8 lb/gal) |
| pH | 6.1 |

**Storage and Handling:**

Nitrogen solution fertilizers such as 28-0-0 are different from anhydrous ammonia in that they do not require high pressure storage and nurse tank applicators.

The nitrogen solution fertilizer most commonly used in Alberta is 28-0-0. It is transported from manufacturing plants to storage tanks at dealer outlets by either railway or most commonly by tanker trucks. Nitrogen solution 28-0-0 is nonflammable, nontoxic and is therefore safe and relatively easy to handle, ship and store.

One problem is that nitrogen solution 28-0-0 is corrosive to some metals. Therefore, equipment that comes in contact with nitrogen solution must be made of resistant materials such as stainless steel, fiberglass, or special plastics. Handling equipment must be washed well with water after use to prevent the solution from drying and sticking to equipment.

**Application:**

There are several methods of applying nitrogen solution fertilizer:

- spray onto soil followed by incorporation
- dribble onto the soil surface
- deep band or shank directly into the soil
- spray directly on crops after emergence
- apply through sprinkler irrigation systems.

It is important that a solution sprayed onto the soil surface be incorporated into the soil. If not incorporated into the soil, the nitrogen in the urea form is subject to losses of $NH_3$ through volatilization, particularly at air temperatures above 10°C. Research has shown that nitrogen solutions tend to give better results when deep banded or shanked into the soil than if sprayed on and incorporated. Other fertilizers such as phosphorus, potassium and sulfur are commonly blended with liquid nitrogen. Application equipment used for nitrogen solutions is discussed in Alberta Agriculture's publication *Fertilizer Application Equipment*, Agdex 542-6.

## PHOSPHORUS FERTILIZERS

### Monoammonium Phosphate (11-48-0 to 11-55-0)

Monoammonium phosphates are the most commonly used dry phosphorus fertilizer sources in Alberta. The properties of these fertilizers are given in Table 5. The amount of phosphorus in a fertilizer is the second number in the formula e.g. 11-51-0, and is given in percent by weight of phosphate ($P_2O_5$).

**Table 5: Properties of Monoammonium Phosphate (11-51-0)**

| | |
|---|---|
| Color | Grey |
| Molecular wt | 115 |
| Solubility in water | High |
| Loose bulk density | 881-993 kg/m³ (55-62 lb/cu ft) |
| Angle of Repose | 30° |
| Water soluble N% | 11.1 |
| Total $P_2O_5$% | 51.2 |
| Total P % | 22.4 |
| Water soluble $P_2O_5$ | 46 |
| Moisture % | 0.8 |
| pH | 4.1 |
| Calcium (Ca) % | 2.0 |
| Sulfur (S) % | 1.8 |
| Iron ($F_2O_3$) % | 0.7 |
| Sodium (Na) % | 0.3 |
| Magnesium (MgO) % | 1.5 |
| Manganese (Mn) ppm | 100 |
| Copper (Cu) ppm | 35 |
| Zinc (Zn) ppm | 130 |
| Molybdenum (Mo) ppm | 13 |

**Storage and Handling:**

Monoammonium phosphate fertilizers are very easily stored and handled. These fertilizers do not absorb moisture during storage. They are also fairly resistant to breakdown during handling.

Monoammonium phosphate fertilizers are completely water soluble.

**Application:**

There are a number of methods of applying these fertilizers:

- drill in with or near the seed
- deep band
- broadcast and incorporate into the soil.

For most crops, drilling in with or near the seed is the most common method. Care must be taken not to apply too much fertilizer with the seed as this can be toxic to the seedling. The maximum rate of $P_2O_5$ that can be placed with cereal crops is 36 kg/ha (40 lb/ac) and with canola is 18 kg/ha (20 lb/ac). Phosphate should not be placed with flax seed at rates above 9 to 14 kg/ha (10 to 15 lb/ac). For specific recommended levels of phosphorus application, Agdex 542-3 *Phosphorus Fertilizer Application in Crop Production* should be consulted. Deep banding is becoming

increasingly popular as a method of applying phosphorus fertilizer.

Recent research has shown that deep banding nitrogen and two-thirds of the phosphate together 10 to 15 cm (4 to 6 in.) below the soil surface, and placing the remaining one-third of the phosphate with the seed gives the maximum fertilizer efficiency and greatest yield. It is important to place both the nitrogen and phosphate in the same deep band. The reason is that plant roots growing out randomly from the seed encounter the nitrogen, which is relatively mobile and diffuses out of the fertilizer band. The roots proliferate in the area of the band and will therefore discover the phosphate which diffuses very slowly in the soil. Also, the nitrification of $NH_4$+ nitrogen to $NO_3$- nitrogen creates an acidic zone which makes phosphorus more available. At the moment, phosphorus fertilizer recommendations in Alberta are currently designed for banding with or near the seed. Recommended rates are not applicable when phosphorus is surface applied and incorporated. If phosphorus is surface applied and incorporated, application rates may have to be two to four times the rate recommended for placement with seed to obtain an equal crop response, where soil test levels for phosphorus are very low.

Phosphorus should be applied according to soil test recommendations. Table 6 shows suggested rates of $P_2O_5$ application at various soil test levels for cereal and canola crops.

Monoammonium phosphate can be blended with either ammonium nitrate or urea to produce various fertilizer blends.

**Table 6: Suggested rates of $P_2O_5$ application at various soil test levels for cereal and canola crops**

*(All recommendations from the laboratory are given in pounds per acre)*

| Soil Test Level P lb/ac (0-6") | RECOMMENDATIONS *($P_2O_5$ lb/ac) Cereals $P_2O_5$ lb/ac | Canola $P_2O_5$ lb/ac |
|---|---|---|
| >50 | 10 | 10 |
| 50 | 10 | 10 |
| 40 | 15 | 10 |
| 30 | 25 | 15 |
| 20 | 35 | 20 |
| 10 | 40 | 25 |
| 0 | 50 | 30 |

*Source: Alberta Agricultural Soil and Feed Testing Laboratory*

** pH - if less than 5.6 then $P_2O_5$ rates should be increased.*
*- if greater than 7.2 and with free lime rates of $P_2O_5$ should be reduced.*

## Diammonium Phosphate (18-46-0)

This is a dry phosphorus fertilizer similar to monoammonium phosphate, but is not commonly used in Alberta. The chemical formula for this fertilizer is $(NH_4)_2HPO_4$. Methods of handling, storage and application of this fertilizer are very similar to those for monoammonium phosphate. The only disadvantage with this fertilizer is that the amount of phosphorus available to plants is slightly less than with monoammonium phosphate.

## Monocalcium Phospate [0-45-0 (Triple Super Phosphate)]

This dry granular fertilizer is similar to monoammonium phosphate. It is not commonly used in Alberta. When used, it is usually blended with other fertilizers. The chemical formula is $Ca(H_2PO_4)_2$. The handling, storage and application of this fertilizer are very similar to those of monoammonium phosphate. The disadvantage is that phosphorus available to plants is slightly less than with monoammonium phosphate.

## Ammonium Polyphosphate Solution (10-34-0)

Ammonium polyphosphate is a fluid. Its use in Alberta has increased in recent years. The chemical formula for it is $(NH_4)_xH_{n+2-x}(P_nO_{3n+1})$. Properties of this fertilizer are given in Table 7.

**Table 7: Properties of ammonium polyphosphate solution**

| | |
|---|---|
| Nitrogen % | 10.0 |
| Total available $P_2O_5$ % | 34.0 |
| Total P % | 14.8 |
| pH | 6.5 to 6.8 |
| Specific gravity | 1.43 |
| Weight per volume | 1.4 kg/litre (14.3 lb/gal) |
| Weight of nitrogen per volume | 0.14 kg/litre (1.42 lb/gal) |
| Weight of $P_2O_5$ per volume | 0.48 kg/litre (4.83 lb/gal) |
| Salt out temperature | -18°C (0°F) |

**Storage and Handling:**

The 10-34-0 fluid fertilizer does require some special handling and storage. This fertilizer is corrosive to some metals. Therefore, equipment that comes in contact with 10-34-0 fertilizer must be made of resistant material. It must also be stored above a temperature of -18°C to keep it in a liquid state.

The 10-34-0 fertilizer is nonflammable, nontoxic and is therefore safe and relatively easy to handle, ship and store.

**Application:**

There are several methods of applying 10-34-0 fertilizers:

- spray on and incorporate into the soil
- dribble onto the soil surface
- deep band or shank directly into the soil
- apply through sprinkler irrigation systems.

It is important to incorporate the immobile phosphorus into the soil. Research has shown that phosphorus fertilizers give the best results when the fertilizer is placed with or

near the seed or deep banded. Deep banding of 10-34-0 is often the most common method of application at the present time, and is superior to spraying and incorporating into the soil. The product is commonly blended with nitrogen, sulfur and potassium.

## POTASSIUM FERTILIZERS

### Potassium Fertilizers (0-0-60, 0-0-62)

Potassium chloride is the major granular fertilizer containing potassium used in Alberta, and is commonly referred to as potash. The chemical formula for this fertilizer is KCl. Some of the physical properties of this fertilizer are given in Table 8. The amount of potassium in a fertilizer is the third number in the formula for fertilizer nutrients and is given in percent by weight of potassium oxide ($K_2O$).

**Table 8: Characteristics of Potassium Fertilizer**

| | |
|---|---|
| Color (0-0-62) | White |
| Color (0-0-60) | Red |
| Molecular wt | 74 |
| Solubility in water (% by wt) | 26% |
| pH | 6.7 |
| Loose bulk density | 1121-1201 kg/m³ (70-75 lb/cu ft) |
| Angle of repose | 32-35° |
| Moisture % | 0.15% |

**Storage and Handling:**

Potassium chloride is very easy to transport, handle and store. Storage in a dry location is the only important factor. Heat or cold will have little effect on this fertilizer. Potassium chloride is not considered a hazardous or poisonous material and is very safe to handle.

**Application:**

There are various ways of applying potassium to the soil. These include:

- placement with or near the seed
- broadcast and incorporate in the soil
- deep band in the soil.

Only recently has there been extensive research on potassium application to soils in Alberta. Potassium should be applied when a soil test shows that soil potassium levels are low. Table 9 shows suggested rates of potassium application at various soil test levels for cereal and canola crops. Higher rates of potassium are required for root crops such as potatoes and sugar beets.

Potassium chloride can be blended safely with both nitrogen and phosphorus fertilizers to make fertilizer grades such as 10-30-10, 8-24-24, 13-13-13 and others. Potassium chloride is also readily soluble in water and can be applied as a liquid fertilizer.

### Other Potassium Fertilizers

Potassium can be applied to the soil in the form of potassium nitrate ($KNO_3$) or potassium sulfate ($K_2SO_4$). These forms of potassium fertilizer are not common in Alberta.

**Table 9: Suggested potassium application rates at various soil test levels for cereal and canola crops**
*(All recommendations from the laboratory are given in pounds per acre)*

| Soil Test Level K lb/ac (0-6") | RECOMMENDATIONS ($K_2O$ lb/ac) Cereals $K_2O$ lb/ac | Canola $K_2O$ lb/ac |
|---|---|---|
| > 290 | 0 | 0 |
| 250 - 290 | 15 | 15 |
| 200 - 250 | 20 | 15 |
| 150 - 200 | 25 | 20 |
| 100 - 150 | 30 | 20 |
| 50 - 100 | 35 | 25 |
| 0 - 50 | 40 | 30 |

*Source: Alberta Agricultural Soil and Feed Testing Laboratory*

- small amounts should be seed placed.

## SULFUR FERTILIZERS

### Sulfur Bentonite [Degra-Sul, and Disper-Sul(0-0-0-90 S)]

This fertilizer is commonly referred to by commercial names such as Agri-sul or Ultra-sul. The fertilizer is approximately 90 percent elemental sulfur and 10 percent bentonite. It is water degradable but not water soluble. Characteristics of this fertilizer are given in Table 10.

**Table 10: Characteristics of Sulfur Bentonite**

| | |
|---|---|
| Color | Greyish yellow |
| Loose bulk density | 993-1173 kg/m³ (62 - 65 lb/cu ft) |
| Forms | Prills or granules |
| Angle of repose | Prills - 30° Granules up to 45° |
| Moisture % | 0.5% |

**Storage and Handling:**

Sulfur bentonite should not be stored or blended with ammonium nitrate. As with all dry fertilizers, sulfur bentonite should be stored in a dry location and transported in covered hoppers. Like all dry sulfur fertilizers, elemental sulfur dust is explosive and therefore must be handled with caution. Sulfur dust will not burn skin or lungs, but will burn eyes. Sulfur is also a very good insulator and will pick up static electricity, therefore electrical handling equipment must be grounded.

**Application:**

Elemental sulfur must be converted by soil micro-organisms to forms such as sulfate ($SO_4^{-2}$) before it can be used by plants. For this reason, crops will not respond

immediately to additions of elemental sulfur. Under normal conditions, four to eight weeks are required before elemental sulfur is converted to an available form for plant uptake. Oxidation of elemental sulfur to sulfate is dependent upon soil moisture, soil temperature, sulfur particle size, and microorganism populations in the soil. Also, fertilizer application methods (broadcast versus banding) can have a significant impact on the rate of sulfur oxidation. When sulfur levels are very low, sulfur bentonite should be used with a fertilizer that contains $SO_4^{-2}$ which is immediately available to the plant.

As with other fertilizers, there are a number of methods of applying sulfur fertilizers. These include:

- placement with or near the seed
- broadcast and incorporate into soil
- deep band into soil.

Deficiencies of sulfur were first identified in Alberta on the Dark Grey and Grey Wooded soils of central and northern Alberta. Some of the Black soils also respond to additions of sulfur. Brown and Dark Brown soils normally have adequate levels of sulfur. Normally, sulfur should only be added to soil after a soil test. Table 11 shows suggested recommendations of sulfur fertilizer based on the soil test level of sulfur. Where subsoils contain higher levels of available sulfur, especially where gypsum is present, crops may not respond to added sulfur fertilizer. Irrigation water normally supplies sufficient sulfur for irrigated crops. Most irrigation water supplies 27 kg/ha (30 lb/ac) of sulfur for every 30 cm (12 inches) of water applied.

**Table 11: Suggested recommendations of sulfur fertilizer based on soil test levels of sulfur**
*(All recommendations from the laboratory are given in pounds per acre)*

| Soil Test S (lb/ac) 0 - 6" depth | RECOMMENDATIONS (S lb/ac) Cereals | Canola & Alfalfa |
|---|---|---|
| 0 - 2 lb/ac | 10 | 15 |
| 2 - 4 lb/ac | 10 | 15 |
| 4 - 6 lb/ac | 5 | 10 |
| 6 - 10 lb/ac | 0 | 5 |
| >10 lb/ac | 0 | 0 |

*Source: Alberta Agricultural Soil and Feed Testing Laboratory*

Generally, when there are more than 9 kg/ha (10 lb/ac) of sulfur in the upper 15 cm (6 in.) of soil, sulfur is not required. Exceptions to this rule include some special crops and row crops.

### Elemental Sulfur

Elemental sulfur (S) can be used as a fertilizer. Agricultural grades of sulfur contain 85-99 per cent sulfur and must pass through a 16 mesh screen.

When applied to aerated, moist soils, elemental sulfur is attacked by soil microorganisms to form sulfuric acid. Sulfuric acid in turn supplies the sulfate ion ($SO_4^{-2}$) which is taken up by plants. Application of elemental sulfur also has an acidifying effect on soils. When elemental sulfur is applied in this form, it will take a considerable length of time to be converted to a plant available form.

### Calcium Sulfate (gypsum)

Gypsum can be used as a sulfur bearing fertilizer material. It is a neutral salt and generally has little effect on soil acidity. It generally contains between 18 and 24 per cent sulfur. The chemical formula is $CaSO_4$.

### Urea-Sulfur (34-0-0-20S to 36-0-0-20S)

Urea sulfur contains elemental sulfur. This fertilizer has finely divided sulfur dispersed throughout the urea granules. Its properties are similar to urea fertilizer 46-0-0. The chemical formula is $(NH_2)_2CO+S$.

### Ammonium Sulfate (21-0-0-24S)

Ammonium sulfate is a common nitrogen and sulfur containing fertilizer. The chemical formula for this fertilizer is $(NH_4)_2SO_4$. This fertilizer can be combined with ammonium phosphate or with urea. It should be noted that 21-0-0-24(S) is the most acidifying of the granular nitrogen fertilizers.

### Urea Ammonium Sulfate (38-0-0-7S to 40-0-0-6S)

This is a mixture of urea and ammonium sulfate. Some forms are manufactured by coating finely divided ammonium sulfate with urea. It has similar properties to urea fertilizer 46-0-0. The chemical formula is $(NH_2)_2CO + (NH_4)_2SO_4$. This fertilizer is not as acidifying as ammonium sulfate and therefore is recommended on acid soils that are sulfur deficient.

### Ammonium Phosphate-Sulfate (16-20-0-14S)

This fertilizer is a homogenous product of mono-ammonium phosphate and ammonium sulfate. It is commonly applied with the seed on soils that are sulfur deficient.

### Ammonium Thiosulfate

This is the most widely used sulfur containing fluid fertilizer. The chemical formula for this fertilizer is $[(NH_4)_2S_2O_3]+NH_3$. The characteristics of this fertilizer are shown in Table 12.

**Table 12: Characteristics of Ammonium Thiosulfate**

| | |
|---|---|
| Thiosulfate % | 56 - 60 |
| Sulfite % | 2 - 2.0 |
| Sulfate % | 1 - 4 |
| pH | 7.5 - 8.5 |
| Specific gravity | 1.32 |
| Total nitrogen % | 11 - 12 |
| Sulfur % | 24 - 26 |
| Weight per volume at 16°C | 1.3 kg/litre (13.2 lb/gal) |
| Weight sulfur per volume at 16°C | 0.34 kg/litre (3.43 lb/gal) |

**Storage and Handling:**

Solutions of ammonium thiosulfate are compatible in any proportion with neutral to slightly acid phosphate containing fluids including liquids, suspensions, and slurries produced from orthophosphates. When blended with ammonium phosphate fluids, the supplemental nitrogen should be supplied as ammonium nitrate, urea or urea-ammonium nitrate solutions. Ammonium thiosulfate can be readily blended with aqueous ammonia and nitrogen solutions, but it is not compatible with anhydrous ammonia. Blending of a wide variety of N-S, N-P-S, and N-P-K-S formulations containing up to 10 to 12 per cent sulfur is possible with relative ease. Problems of salting out can occur when mixing ammonium thiosulfate with potassium chloride and ammonium nitrate or urea-ammonium nitrate solutions.

Ammonium thiosulfate is non-corrosive and may be stored in steel or aluminum containers. It should not come in contact with tin, copper or brass. Storage temperatures should be kept between -1.0° and 38°C (30 and 100°F).

**Application:**

There are several methods of applying ammonium thiosulfate. These include:

- spray on soil and incorporate
- deep band into soil, usually in a blend with other fertilizers
- apply using sprinkler systems.

## MICRONUTRIENT FERTILIZERS

Micronutrient deficiencies seldom occur in Alberta. To determine if a micronutrient is deficient, refer to the fact sheet titled *Micronutrient Requirements of Crops in Alberta* Agdex FS 531-1. There are many types and kinds of micronutrient fertilizers, and therefore only a few of the more common forms will be discussed.

### Micronutrient Fertilizer Forms

Micronutrient fertilizers can occur in different forms. The three principal kinds of micronutrient fertilizers include:

*Inorganic* - readily soluble inorganic salts

*Organic* - synthetic and natural chelate compounds

*Fritted Glasses* - prepared by fusing micronutrient salts with silicate compounds into a glasslike product.

The inorganic sources include naturally occurring ores and manufactured oxides or metallic salts. The sulfates are the most common of the metallic salts. They are made by treating the insoluble ground ore or oxide containing the desired micronutrient with sulfuric acid ($H_2SO_4$) to produce a soluble crystalline material. This can then be made into a granular form. The sulfates are the most economical salts and their physical properties make them suitable for mixing with other fertilizers. Some common inorganic micronutrient fertilizers are given in Table 13.

**Table 13: Some common inorganic micronutrient fertilizers**

| Nutrient | Form | Percent of Nutrient in Product |
|---|---|---|
| Boron | Borate | 12 - 20% |
| | Borax | 11% |
| Chlorine | Potassium chloride (0-0-60) | 40% |
| Copper | Copper sulfate | 25% |
| Iron | Iron sulfate | 19% |
| Manganese | Manganese sulfate | 26% |
| Molybdenum | Sodium molybdate | 39 - 47% |
| Zinc | Zinc sulfate | 18 - 23% |

The organic sources of micronutrients are the synthetic and natural chelates. A chelate is a negatively charged organic compound to which a positively charged metal is bonded and the combination may or may not be soluble in water. The synthetic chelate materials are quite expensive but are claimed to be more effective than the inorganic salts thus making them competitive on an economic basis. For some fluid fertilizers, chelates have the advantage of remaining in solution. Metal salts react to form complexes or precipitates in some phosphorus fertilizers which interfere with uniform distribution unless the fertilizer is agitated. Important research work done in Nebraska has shown that some chelates applied to high pH, calcareous soils break down very rapidly and therefore are not available to the plant. This maybe an important factor in the Brown and Dark Brown soil zones in Alberta.

### Application of Micronutrient Fertilizers

Micronutrients may be soil or foliar applied. Soil applied micronutrients may be broadcast and incorporated or banded into the soil. They may be applied as individual sources or mixed with other fertilizers. There is conflicting information as to which types of micronutrient fertilizers are most effective and whether soil or foliar applications of micronutrients are best. Therefore, recommendations cannot be made as to which fertilizer or method of application is best. Care must be taken to select micronutrient sources and mixed fertilizer which, when combined, will result in products that supply micronutrients in an available form.

**Bulk blending with granular fertilizers:**

Micronutrients that are finely ground or in granular form can be blended with other granular fertilizers. This allows more flexibility in changing proportions to meet the specific needs of the farmer. The blending can also be done just before application to reduce the chance of undesirable chemical reactions. Care must be taken to allow a long enough mixing time to obtain a uniform mix, because of the small amount of micronutrient fertilizer being blended with the large amount of macronutrient fertilizer. A disadvantage of some granular micronutrient fertilizers is that they have greasy or oily characteristics making them somewhat undesirable to handle. Bulk blending of macronutrient and micronutrient fertilizers is common. The blends are then either broadcast and incorporated or banded into the soil.

**Coating onto granular fertilizers:**

Finely ground micronutrient materials may be coated onto granular fertilizers to prevent segregation. Normally, coating agents such as water, oil, waxes or fertilizer salt solutions are used. Coating agents must be inexpensive, stick to the fertilizer during handling and not cause undesirable physical or chemical products.

**Mixing with fluid fertilizers:**

Mixing micronutrients with fluid fertilizers is a common method of application in Alberta. The biggest advantage is that uniform mixes can be obtained. Solubility of micronutrients is a limiting factor in supplying sufficient quantities for plant use. Several of the nitrogen solutions are good carriers of micronutrients and most are soluble in polyphosphate base solutions such as 10-34-0. Fluid fertilizers containing micronutrients can be banded directly into the soil or can be pre-plant applied by sprayer onto the soil surface and then incorporated. These same fluid fertilizers can also be sprayed directly onto crop foliage. Irrigation systems can be used for applying fluid fertilizers.

## BULK HANDLING OF FERTILIZERS

### Dry Fertilizers

Granular fertilizers are normally transported from manufacturing plant to bulk fertilizer plants either by hopper-bottom railway cars or transport trucks. At the bulk plant, fertilizer is stored in bins. Granular fertilizers are often removed from the storage bins by a front-end loader. They are weighed in a scale hopper which is mounted above an inclined portable belt conveyor that empties into the bulk application truck. Figure 4 shows a typical example of this. Another typical bulk handling system is shown in Figure 5. In this case, materials from the storage bins are dumped into applicators and are weighed on truck scales.

There are many types of bulk blending plants. In most cases they use a rotary mixer similar to the conventional concrete mixer used to transport concrete from a basic mixing plant to the point of use. In other instances the concrete mixer is of the type that can be charged at one end and discharged at the other. This is superior to the conventional portable concrete mixer. Equipment is arranged in one of two ways. The first is referred to as the vertical-flow type which has the mixer installed in an elevated position and the fertilizers are conveyed and elevated to it. Figure 6 shows a typical example. A second type has the rotary mixer installed at ground level, shown in Figure 7. In this case materials are elevated to a weigh device which discharges into the rotary mixer. The mixer is charged at one end and discharged at the other end.

### Solution Fertilizers

Most solution mixing plants are very similar; all require storage tanks, meters and pumps. Basically, the amounts of each type of fertilizer are metered out of each storage tank and pumped into a nurse tank. A typical example of this is shown in Figure 8.

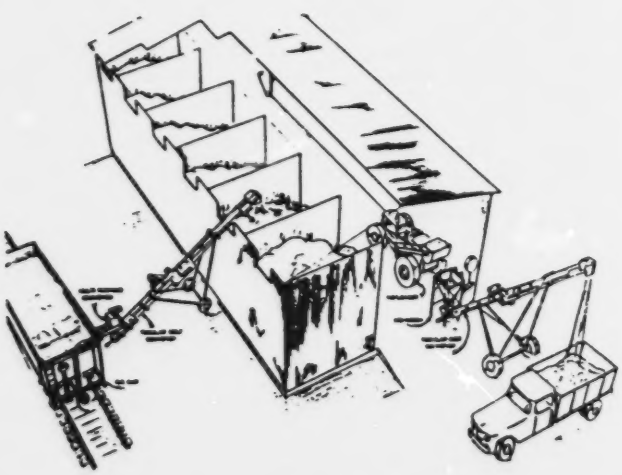

*FIGURE 4: Ground storage bulk blending station*

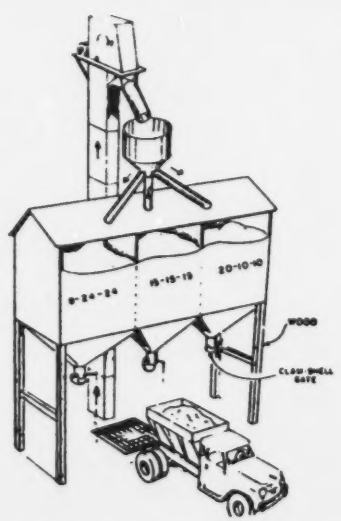


*FIGURE 5: Bulk handling station with elevated storage*

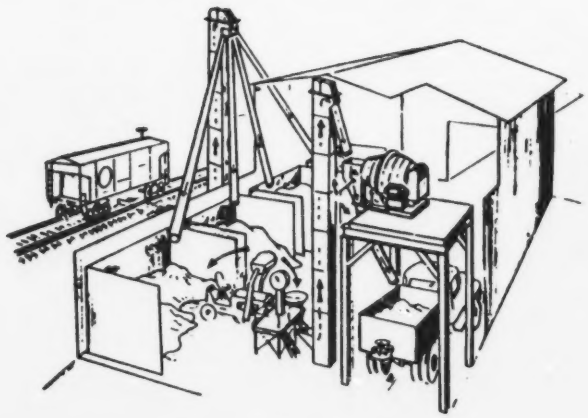

*FIGURE 6: Blend plant with elevated rotary mixer*

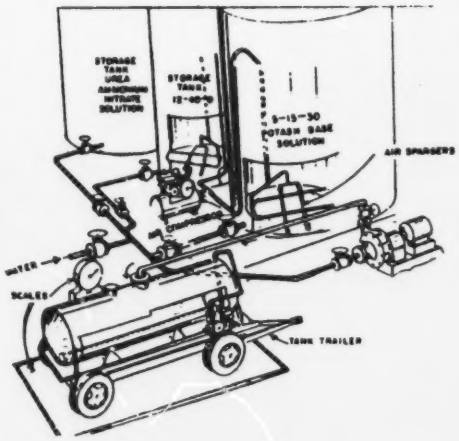

*FIGURE 8: Satellite cold blending suspension station*

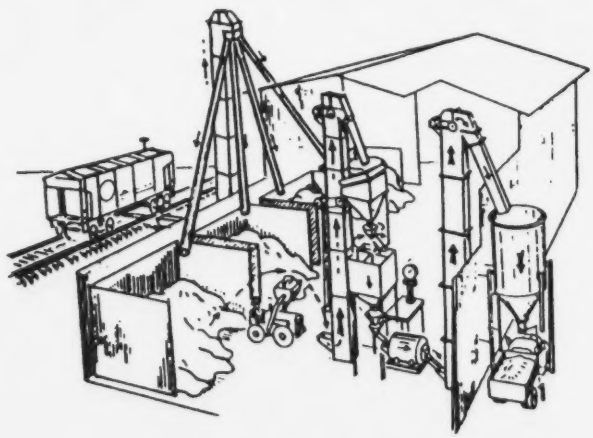

*FIGURE 7: Plant with rotary mixer at ground level*


## ACKNOWLEDGEMENTS

Figures 1, 2 and 3 are taken from "Agricultural Anhdrous Ammonia — Technology and Use". Soil Science Society of America, Madison, Wisconsin. 1966. Permission to reprint requested.

Figures 4, 5, 6, 7 and 8 are taken from "Fertilizer Technology and Use" 2nd Edition. Soil Science Society of America Inc., Madison, Wisconsin, 1971. Permission to reprint requested.



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